

CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Thirty-second meeting of the Animals Committee
Geneva (Switzerland), 19-23 June 2023

Species conservation and trade

PANGOLINS (*MANIS* SPP.)

1. This document has been prepared by the Secretariat.
2. At its 19th meeting (CoP19; Panama City, 2022), the Conference of the Parties adopted a set of [Decisions on Pangolins \(*Manis spp.*\)](#). Decisions 18.238 and 18.239 were renewed and Decisions 19.200 to 19.204 were adopted. Of these, Decisions 18.239 and 19.200 as follows are of most relevance to the Animals Committee:

Directed to the Secretariat

18.239 *The Secretariat shall, subject to external funding, work with the Species Survival Commission Pangolin Specialist Group of the International Union for Conservation of Nature (IUCN) and other relevant experts and in collaboration with the pangolin range States to develop conversion parameters for all pangolin species, that will enable the reliable determination of the number of animals associated with any quantity of pangolin scales seized, that can be used by Parties in cases where national legislation demands that such information be provided for court purposes.*

Directed to the Animals Committee

19.200 *The Animals Committee shall:*

- a) *review the conversion parameters for all pangolin species, developed in accordance with the provisions of Decision 18.239, to enable the reliable determination of the number of animals associated with any quantity of pangolin scales seized, and that can be used by Parties in cases where national legislation demands that such information be provided for law enforcement and court purposes;*
- b) *review existing identification materials concerning pangolin species, their parts and derivatives, and consider the need for new or additional materials to be developed, including to support the identification of seized pangolin specimens at species level;*
- c) *review any information brought to its attention by the Secretariat in accordance with Decision 19.203, paragraphs b) and e); and*
- d) *make recommendations, as appropriate, to the Standing Committee and the Secretariat.*

Directed to the Secretariat

19.203 *The Secretariat shall:*

- a) *issue a Notification inviting Parties, international organizations, international aid agencies and non-governmental organizations that developed tools and materials that could assist Parties in the implementation of Resolution Conf. 17.10 (Rev. CoP19) or identification materials*

concerning pangolin species, their parts and derivatives, to bring such materials to the attention of the Secretariat;

- b) bring any materials reported in accordance with paragraph a) of the present Decision to the attention of the Animals Committee or the Standing Committee, as appropriate, together with any recommendations it may have, and taking into account any subsequent recommendations from the Animals Committee or the Standing Committee, make such materials available to the Parties;
- c) subject to external funding, provide training to Parties on the identification of pangolin specimens;
- d) work with its partners in the International Consortium on Combating Wildlife Crime (ICWC) to initiate activities and support the efforts of Parties to address illegal trade in Pangolin specimens;
- e) report on the implementation of Decisions 18.238 and 18.239 to the Animals Committee, together with any recommendations it may have;
- f) report on the implementation of Decision 19.202 to the Standing Committee, together with any recommendations it may have; and
- g) report to the 20th meeting of the Conference of the Parties on the implementation of the present Decision.

Implementation of Decisions 18.239 and 19.200, paragraph a)

3. Decision 18.239 has been implemented thanks to a financial contribution from France to the Strategic Programme of the International Consortium on Combating Wildlife Crime (ICWC). The Secretariat worked with the Species Survival Commission Pangolin Specialist Group of the International Union for Conservation of Nature (IUCN), hereafter referred to as “the pangolin specialist group”, to develop conversion parameters for all pangolin species, that will enable the reliable determination of the number of animals associated with any quantity of pangolin scales seized, in collaboration with the pangolin range States. The final report is presented in the Annex to this document.
4. The report states that “development of conversion parameters requested by the CITES Parties requires data on scale mass for each pangolin species”. As published estimates were already available for the Chinese (*Manis pentadactyla*) and Sunda pangolins (*M. javanica*) (Zhou et al. 2012), the principal focus of this project was to collect primary data on scale mass for the six other pangolin species: *M. culionensis*, *M. crassicaudata*, *M. tetradactyla*, *M. tricuspis*, *M. gigantea*, and *M. temminckii*.
5. Due to the COVID-19 pandemic, international travel was not possible until April 2022, so assistance from range States and local collaborators was necessary to collect data. A sampling protocol was therefore developed to facilitate this data collection, which can be found in the Annexes to the report.
6. The available data on scale mass for the eight pangolin species is presented in summarised form in the report and in the table below:

Table 1. Scale mass estimates based on contributed data to 8/11/2022.

Species	No. of specimens	Mean scale mass (and range)**	Source(s)
<i>M. pentadactyla</i>	35	592.98 (129.4–1121.07) g	Zhou et al. (2012)
<i>M. javanica</i>	123	370.31 (106.14–824.54) g	Zhou et al. (2012); this study
<i>M. culionensis</i> *	21	368.28 (275–553) g	This study
<i>M. crassicaudata</i>	9	1063.82 (56.25–2099.6) g	This study
<i>M. tricuspis</i>	29	188.35 (115.5–342) g	This study

<i>M. tetradactyla</i> †	28	186.74 (118–318.82) g	This study
<i>M. gigantea</i> †	22	3939.57 (2654–4969) g	This study
<i>M. temminckii</i> ‡	18	1824.39 (342.25–3230.08) g	This study

*Based on estimating scale frequency in order to estimate scale mass from already detached scales.

†Based on scale mass estimates using the “reconstruction” method for 21x *M. gigantea* and 20x *M. tetradactyla*.

‡Based on skins with scales attached rather than cadavers for 10x specimens.

**For species other than *M. pentadactyla* and *M. javanica*, the estimates are based on fewer than 30 specimens, which the Parties may wish to consider when using these parameters for their intended purpose.

7. The report concludes by outlining a number of next steps that need to be taken, including further data collection and examination of bias associated with the estimates, before scale mass estimates for all eight pangolin species can be considered robust to derive the finalised conversion parameters. The pangolin specialist group have indicated that they have secured additional funding through a Pangolin Crisis Fund project titled “[Developing Robust Conversion Parameters for Seized Pangolin Scales](#)” that enabled this research to be carried out through 2022 and into 2023. An update on progress may be provided by the pangolin specialist group at this meeting that will improve the accuracy of the scale mass estimates in Table 1 above.

Implementation of Decisions 19.200, paragraphs b) and c) and 19.203

8. Concerning the implementation of Decisions 19.200, paragraphs b) and c) and 19.203, the Secretariat issued Notification to the Parties No. 2023/051 on materials for the identification of specimens of CITES-listed species on 20 April 2023, including a request to Parties, international organizations, international aid agencies and non-governmental organizations that developed tools and materials that could assist Parties in the implementation of Resolution Conf. 17.10 (Rev. CoP19) on *Conservation of and trade in pangolins* or identification materials concerning pangolin species, their parts and derivatives to bring such materials to the attention of the Secretariat. The Secretariat will bring any relevant materials reported in response to the Notification to the attention of the Animals Committee at its next meeting and will refer any identification material to the joint working group on identification materials to be established by the Animals and Plants Committees under Decision 19.142.

Recommendations

9. The Animals Committee is invited to:
- a) consider the report in the Annex to this document and any updates provided by the pangolin specialist group (in particular, any revisions or updates to Table 1 in paragraph 6 above); and
 - b) make recommendations to the Secretariat and the Standing Committee, as appropriate, on the conversion parameters developed for all eight pangolin species.



**Development of conversion parameters to
estimate the number of pangolins (*Manis* spp.)
from quantities of scales**

November 2022

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Prepared under contract from the CITES Secretariat by Daniel W.S. Challender and Matthew H. Shirley from the International Union for Conservation of Nature.

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1. Introduction

At the 18th meeting of the Conference of the Parties (CoP18, Geneva, 2019), the CITES Parties adopted a suite of Decisions relating to pangolins, including Decision 18.239. This Decision directs the CITES Secretariat, subject to external funding, to work with the Species Survival Commission Pangolin Specialist Group of the International Union for Conservation of Nature (IUCN) and other relevant experts, and in collaboration with pangolin range States, to develop conversion parameters for all pangolin species that will enable the reliable determination of the number of animals associated with any quantity of pangolin scales seized, that can be used by Parties in cases where national legislation demands that such information be provided for court purposes. Decision 18.240 paragraph a) directs the Secretariat to report on the implementation of Decision 18.239, to the Animals Committee. Decision 18.243 directs the Animals Committee to review any information brought to its attention by the Secretariat in accordance with Decision 18.239 and make recommendations as appropriate to the Standing Committee and the Secretariat.

In December 2020, having acquired the necessary external funding, the CITES Secretariat contracted the IUCN to undertake the work referred to in Decision 18.239 in consultation with the CITES Secretariat and working with relevant experts and pangolin range States.

The development of conversion parameters requested by the CITES Parties requires data on scale mass for each pangolin species. Despite increasing research effort on pangolins in the last two decades (Heighton and Gaubert, 2021; Challender et al., 2020), and other research that may be informative for converting scale quantities into equivalent whole pangolins (EWP) (e.g., pangolin scale frequency; Ullmann et al., 2019), there remains a paucity of data on scale mass. Exceptions are published estimates for the Chinese (*Manis pentadactyla*) and Sunda pangolins (*M. javanica*) (Zhou et al. 2012). Consequently, the principal focus of this project was to collect primary data on scale mass for the six other pangolin species: *M. culionensis*, *M. crassicaudata*, *M. tetradactyla*, *M. tricuspis*, *M. gigantea*, and *M. temminckii*.

Due to the COVID-19 pandemic it was not possible for the authors to travel internationally to collect data with local collaborators as originally intended until April 2022. The project was therefore principally managed remotely, and the authors are grateful to the CITES Parties, their agencies, and all collaborators (Annex 1) for their engagement, and for collecting data and

contributing to this project. With additional financial support provided by the Pangolin Crisis Fund, the authors were able to travel to Cameroon, Kenya, Nigeria, and Uganda in 2022 to collect data for this project with local collaborators and the authors thank these Parties for providing permission to conduct the research and for hosting them while in-country.

2. Methodology

Accurate estimation of the number of pangolins involved in a given seizure of scales necessitates knowledge of: (1) the proportion of body mass that comprises scales for the different species of pangolin, and (2) the proportion of scales from the different species in seizures. This report principally focuses on the former of these two data needs, i.e., generation of data on scale mass. The aim of the project was to collect data on scale mass for 30+ specimens each of *M. culionensis*, *M. crassicaudata*, *M. tetradactyla*, *M. tricuspis*, *M. gigantea*, and *M. temminckii*; as well as 5+ additional specimens each of *M. pentadactyla* and *M. javanica* to supplement the data published in Zhou et al. (2012), which were shared with the authors for the purposes of this project, and complement the data collected here for the production of scale identification products. See Section 4 (Next steps) for discussion on data needs regarding seizure composition.

In March 2021, we contacted all pangolin range States by email using contact details available on the CITES website and invited them to collaborate on implementing Decision 18.239. This included all Management, Scientific, and Enforcement authorities. Where the authors had more up-to-date contact details for particular individuals within these agencies those contact details were used. This entailed contacting 164 and 124 individuals in African and Asian pangolin range States, respectively. Additionally, we contacted the (at the time) 148 members of the IUCN SSC Pangolin Specialist Group, as well as other individuals known to be researching and/or rehabilitating pangolins and invited them to collaborate on this project if they were willing and able to contribute data on scale mass for one or more pangolin species. Following initial contact with the above individuals and agencies, we used a snowball approach to identify further individuals and organisations that may have potential access to pangolin cadavers either immediately, or in the future, including NGOs, conservation practitioners, academic institutions, museums, zoological gardens, and wildlife rescue centres primarily within, but not limited to, pangolin range States.

In March and April 2021, the authors held virtual meetings (using Zoom) with individuals and agencies, either bilaterally or with groups of potential collaborators, during which detailed information about this project was shared, including the aims, data collection protocols, and available funding to support data collection. These meetings were offered in English and French across a range of time zones in order to encourage participation.

We subsequently provided the organisations, agencies, and individuals (Annex 1) who either could, or had the potential to, provide data with a detailed data collection protocol (Annex 2) in English and/or French to guide data collection. This was to ensure that data were collected in a standardised manner using the same methodology. We also provided collaborators with soft copies of data collection sheets (in MS Excel) in English and/or French to ensure standardised data collection and reporting. We informed all potential collaborators about the importance of making sure that any collected data that would contribute to this project was to be collected legally, that appropriate research permits were acquired prior to data collection, and that pangolins were not to be purchased (e.g., from markets) or otherwise sacrificed to collect data to inform this study. No pangolins were sacrificed for this project and all methods were reviewed by Florida International University’s Institutional Animal Care and Use Committee (IACUC-18-013-AM05).

We asked collaborators to collect data at one of three levels according to the availability of their time and resources:

- **Tier 1:** comprised the collection of data on overall scale mass and the taking of 10 accompanying photos for each specimen. This was the most basic form of data collection and Tier 1 data were the minimum required to contribute to the development of conversion parameters.
- **Tier 2:** comprised the collection of Tier 1 data and accompanying photographs, as well as an additional 6 scale mass estimates (by body region) and 9 additional photographs per specimen.
- **Tier 3:** comprised the collection of Tier 2 data and additional measurements of scale thickness, pliability, and the mass of selected scales (see also Annex 2). Tier 2 and 3 data will be used to inform the development of tools that go beyond implementation of Decision 18.239, including a pangolin scale identification guide (see Section 4).

For two species—*M. culionensis* and *M. temminckii*—there was a need to deviate from the data collection protocol in Annex 2. The Palawan Council for Sustainable Development (PCSD) in the Philippines advised the authors that although they possessed 21 *M. culionensis* cadavers, the cadavers had previously been descaled and the scales were in the possession of PCSD. As such, we prepared an amended data collection protocol (Annex 3) that relied on “scale matching” and

a guide on the size and shape of scales based on *M. javanica* (Annex 4)—from which *M. culionensis* was distinguished only in 2007 (Gaubert et al., 2005)—for PCSD in order for them to provide the best estimate possible of *M. culionensis* scale mass.

For *M. temminckii*, while it was possible for some collaborators (e.g., South African National Biodiversity Institute; SANBI) to access cadavers, other collaborators in southern Africa, including the Ministry of Environment and Tourism, Namibia, only had access to *M. temminckii* skins with the scales attached. In these circumstances, a solution comprising 25% ammonia and 75% water was applied to the skins to soften the tissues prior to the removal of scales. The authors are awaiting the final protocol for this method from collaborators in Namibia and on receipt of the protocol, a next step is to collect additional data on this species – see Section 4 (Next steps).

In April 2022, when international travel restrictions had been relaxed, it was possible for the authors to travel internationally to collect data with local collaborators in pangolin range states. The authors travelled to Nigeria and Cameroon in April 2022 and to Kenya and Uganda in August 2022 to collect data from pangolin scales that had been seized and were held in stockpiles in these countries. This enabled data collection on scale mass for *M. gigantea* and *M. tetradactyla*, as well as seizure composition (see Section 3 and 4). For scale mass, there was a need to deviate from the data collection protocol in Annex 2. To generate data from seized scales, we separated scales from *M. gigantea* and *M. tetradactyla*, respectively, based on morphology into different piles representing the following body regions from which they originated: head, forelimbs and hindlimbs, trunk, tail-dorsal, tail-ventral, and tail-lateral. Using published (Ullmann et al. 2019) and unpublished (M. Shirley, unpubl. data) data on scale frequency, we calculated the number of scales present on each of the aforementioned body regions for each species, including known variation from the above sources. This enabled us to use a random number generator in MS Excel to estimate the number of scales needed to “reconstruct” *M. gigantea* and *M. tetradactyla* specimens, both overall and by body region. We used this information to randomly draw scales from each body region pile to reconstruct 21 and 20 sets of independent *M. gigantea* and *M. tetradactyla* scales, respectively. These independent sets of body region mass measurements will be used to estimate total scale mass from hundreds of “reconstructed” specimens (see Section 4, Next steps).

In addition, the method of collecting data from skins with the scales attached was used for a small number of *M. gigantea* and *M. temminckii* specimens that were made available to us in Uganda.

Limitations

There were a number of limitations to the progress made on this project. First, due to the COVID-19 pandemic it was not possible for the authors to travel internationally to undertake data collection with local collaborators in pangolin range States until 2022. Had such travel been possible earlier, it may have been possible to increase the sample size achieved for the different pangolin species (see Section 3, Results).

Second, as the report authors were not able to travel internationally for the majority of the project duration, data collection was dependent on the willingness of the CITES Parties and other organisations to collaborate, issue permits, acquire specimens, and commit the time and resources to data collection. This was possible in many cases, but by 8th November 2022 it had not been possible to reach the target sample size (30+) for all pangolin species (see Section 3, Results). There is adequate data to develop more final conversion parameters for *M. pentadactyla*, *M. javanica*, *M. gigantea* and *M. tetradactyla*. The authors are awaiting the receipt of further data from a number of collaborators for other species but even with the additional data, it is unlikely that the target of 30+ specimens will be achieved for *M. culionensis*, *M. crassicaudata*, and *M. temminckii* in 2022. It may be possible for *M. tricuspis* and *M. temminckii* specimens, which are more easily accessible.

Third, in some cases, it is apparent from collaborators that cadavers for particular species—most prominently *M. crassicaudata*—are infrequently encountered in the condition needed to collect data for this project. For example, in Sri Lanka the availability of *M. crassicaudata* cadavers is dependent on the confiscation of specimens from poaching and/or roadkill incidents, events that seemingly occur infrequently.

While data is available for all eight pangolin species (see Section 3, Results), robust sample sizes are still needed for six of the eight pangolin species in order to develop reliable conversion parameters, especially at the continent- and family-level (i.e., for the Manidae). For some species (e.g., *M. temminckii*), there is apparent and significant geographically-correlated variation in individual size and, therefore, expected scale mass which, if uncaptured, will result in biased estimates. See Section 4 (Next steps) on additional steps to be taken on the collection of additional data and verification of conversion parameters.

3. Results

The available data on scale mass for the eight pangolin species is presented in summarised form in Table 1. Adequate sample sizes have been achieved for *M. pentadactyla* and *M. javanica*, largely because they are based on data published in Zhou et al. (2012). The mean scale mass estimates for these species presented here differ from those published in Zhou et al. (2012). For *M. pentadactyla*, this simply reflects re-analysis of the raw data in Zhou et al. (2012). For *M. javanica*, this reflects an increase in available data from which to inform the estimate. The results demonstrate both the inter- and intra-specific variation in scale mass for pangolins underlying the importance of developing species-, continent-, and family-level conversion parameters and their appropriate use thereafter.

Preliminary research conducted on the African pangolins has shown that estimates of the number of arboreal African pangolins (*M. tricuspis* and *M. tetradactyla*) in seizures using published scale mass estimates for *M. javanica* (as a proxy for Manidae spp.) significantly underestimate the number of individuals in illegal trade by 30-50% or more (M. Shirley et al., In prep.). Zhou et al. (2012) recommend using their scale mass estimates for *M. pentadactyla* and *M. javanica* in judicial proceedings. For other species it should be noted that sample sizes of 30 or more specimens have not yet been achieved (Table 1).

Table 1. Scale mass estimates based on contributed data to 8/11/2022.

Species	No. of specimens	Mean scale mass (and range)**	Source(s)
<i>M. pentadactyla</i>	35	592.98 (129.4–1121.07) g	Zhou et al. (2012)
<i>M. javanica</i>	123	370.31 (106.14–824.54) g	Zhou et al. (2012); this study
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*Based on estimating scale frequency in order to estimate scale mass from already detached scales.

†Based on scale mass estimates using the “reconstruction” method for 21x *M. gigantea* and 20x *M. tetradactyla*.

‡Based on skins with scales attached rather than cadavers for 10x specimens.

**For species other than *M. pentadactyla* and *M. javanica*, the estimates are based on fewer than 30 specimens, which the Parties may wish to consider when using these parameters for their intended purpose.

In addition to current limitations due to samples size, over the course of this work several other sources of bias have been identified and should be further explored prior to using these conversion parameters (see Section 4, Next steps). These sources of bias are as follows:

- Existence of intra-specific variation in scale mass due to the following factors:
 - Natural variation between individuals.
 - Variation between adults, sub-adults, and juvenile animals.
 - Variation related to as yet well understood preliminary evidence for divergent evolutionary significant units and/or cryptic pangolin species within currently recognized taxa (e.g., Gaubert et al. 2016, Hu et al. 2020).
 - Ecologically-driven heterogeneity resulting in size variation across individual species’ ranges. For example, *M. temminckii* is smaller in the Kalahari than in other regions of South Africa (Pietersen et al., 2020), all of which appear significantly smaller than individuals in East and northern Central Africa (this study, and C. Okell, pers. comm.).

- Variation in scale mass estimation and/or conversion to EWP based on the condition of the scales, including:
 - Age of scales (i.e., length of time between removal from the pangolin and further measurement), including both for derivation of conversion parameters and in consignments/seizures to be converted to EWP.

- State of desiccation of scales (i.e., have the scales been dried and for how long), including both for derivation of conversion parameters and in consignments/seizures to be converted to EWP.
- Decomposition of scales in consignments/seizures to be converted to EWP (i.e., well preserved and stored in a dry environment out of the sun versus exposed to the elements and in varying states of decomposition).
- Presence of skin, dirt, and other debris attached to scales.
- Composition of scales within any single seizure (i.e., a single, universal conversion parameter is unlikely to be informative). To this end, we have collected data on species composition in seizures of scales stored in Cameroon, Cote d'Ivoire, Kenya, Nigeria, and Uganda. To date, we have collected data on at least 57 seizures in these countries, involving 569 bags or containers and >22 tonnes of scales. This data is helping inform our expectations for species composition at the container and consignment levels, including any geographical correlations.

4. Next steps

There are a number of next steps that need to be taken, including further data collection and examination of bias associated with the estimates, before scale mass estimates for all eight pangolin species can be considered robust to derive the finalised conversion parameters. The authors of this report have secured additional funding through a Pangolin Crisis Fund project titled “[Developing Robust Conversion Parameters for Seized Pangolin Scales](#)” that will enable this research to be carried out through 2022 and into 2023.

Additional data collection

- Liaise with collaborators—existing and new—to increase sample sizes to 30+ individuals for each species where this has not yet been achieved. This may involve the authors travelling to, and collaborating with, agencies in pangolin range States, as well as continuing to work with collaborators remotely. To this end, we call on all Parties to CITES, and any other stakeholders, to continue facilitating these efforts wherever possible.
- Where data have been collected using the “reconstruction” method, finalise the protocol for estimating scale mass for additional specimens using recombination of data for body regions. This will increase the sample size for these species substantially.
- Devise a plan for developing conversion parameters for species for which collecting 30+ samples is not possible by end-June 2023.
- Examine variation in scale mass estimates within demographic groups (adults, sub-adults, and juveniles) and across sampling localities for all species.
- Examine how scale mass estimates vary based on condition (e.g., desiccated vs. wet, new vs. old, rotten vs. intact, etc.).

Assessment of species composition in seizures

- Building on existing data collection (see Section 3), investigate species composition of further seizures to develop expectations and models of species composition based on consignment characteristics (e.g., origin, transit, destination, etc.). We continue to liaise with a number of Parties (e.g., Singapore and Thailand) which are willing to notify us if and when seizures are made and become available for data collection. To this end, we call on all Parties to CITES, and any other stakeholders, to continue facilitating these efforts wherever possible.

- As for data collection to date, when sorting through scale seizures, we will identify all scales to species level where possible, or to genus level where not possible, and re-weigh the seizure on a species-by-species basis to estimate proportion of each species in each seizure. We will implement several different sub-sampling regimes alongside our comprehensive sampling to better inform the development of guidance for Parties (see Outputs below). We will collect seizure data (e.g., country of seizure, shipping information, transit, and origin countries), where known, to develop geography-specific expectations of species composition.
- Apply the conversion parameters to scale seizures and make recommendations for their application under different species composition scenarios.

Outputs

- Use newly developed conversion parameters with species composition data to provide updated and more accurate estimates of the scale of global pangolin trafficking in terms of numbers of pangolins.
- Develop a guidance document (including a decision tree) on using the scale conversion parameters developed for use by CITES Parties and other stakeholders. This will include guidance on estimating the number of individual pangolins involved based on species/species combinations and country/region/continent formulas/models of species composition in seizures.
- Develop an illustrated pangolin scale identification guide based on data and materials (e.g., photos) collected as part of this project.
- Develop an automatic conversion tool for use by range States and other stakeholders that includes species, genera, and geography-specific conversion parameters, as well as spatial models accounting for species composition in seizures. The tool will likely take the form of a smartphone app or an Excel spreadsheet with macros, in both cases users will respond to a series of questions and provide a set of input data to derive the number of EWP.
- Devise judiciary recommendations on the use of conversion parameters and the estimated numbers of EWP.

These products will be made available to the CITES Parties, other interested stakeholders, and through peer-reviewed publications as soon as possible.

5. References

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Annex 1. List of agreed and potential collaborators

Country	Name	Organisation
Angola	Albertina Nzuzi	National Directorate of Biodiversity
Bangladesh	Mihir Doe	Bangladesh Forest Department
Bangladesh	Rathindra Kumar Biswas	Bangladesh Forest Department
Benin	Stanislas Zanvo	Universite Abomey-Calavi
Benin	Ulysse Korogone	CITES MA
Benin	Josea Doussou-Bodjrenou	Nature Tropicale / EAGLE
Benin	Marc Sylvestre Djagoun	Universite Abomey-Calavi
Bhutan	Tshering Nidup	MOAF (CITES MA)
Cameroon	Alain Delon	
Cameroon	Ghislain Fopa	
Cameroon	Esong Lionel Ebong	
Cameroon	Simo Franklin Talla	
Central African Republic	Tessa Ullmann	Sangha Pangolin Project
Côte d'Ivoire	Guy-Brou Mathieu Assovi	Project <i>Mecistops</i>
Côte d'Ivoire	Sere Gonedele Bi	Universite Felix Houphouet-Boigny
Côte d'Ivoire	Jofi Jules Gosse	Universite Felix Houphouet-Boigny
Côte d'Ivoire	Oumar Bile Kante	CALAO
Côte d'Ivoire	Raymond Taha	Vision Verte
Côte d'Ivoire	Rens Ilgen	EAGLE (Togo, Cote d'Ivoire, Guinea)
DR Congo	Benezeth Visando	
DR Congo	Jonas Nyumu	
DR Congo	Claude Keyboy	SynergieRurale-Action Paysanne ((SyR-AP)
DR Congo	Michelle Wieland / Juliet Wright	Wildlife Conservation Society
Ghana	Augustine Yeboah	
Ghana	James Oppong	Forestry Commission, Ghana (CITES MA)
Ghana	Daryl Bosu	A Rocha Ghana
Ghana	Kofi Amponsah-Mensah	University of Ghana
Ghana	Yaw Boakye Agyeman	University of Energy and Natural Resources
Ghana	Agro Prince Pascal	Pangolin-GH
Ghana	Daniel Konzin	Kakum Conservation Area

Ghana	David Kwarteng	University of Cambridge
Ghana	Bernard Asamoah-Boateng	Forestry Commission, Ghana (CITES MA)
Ghana	Mercy Oduro Koomson	CITES MA
India	Rajesh Mohapatra	Nandankanan Zoo
Kenya	Bernard Agwanda	National Museums of Kenya
Liberia	Richard Nesbitt	Friends of Liberia
Liberia	Jim and Jenny Desmond	Liberia Chimpanzee Rescue and Protection
Liberia	Angelique Todd/Mary Molokwu/Michelle Moeller	FFI
Liberia	Deemie Dickarmien	Independent
Liberia	Julie Vanassche	Libassa Wildlife Sanctuary
Mozambique	Nunes Tomas Mazivile	CITES MA
Namibia	Kelsey Prediger	NPWG
Namibia	Fillemon Iifo	Ministry of Environment and Tourism
Niger	Seyni Abdoul-Aziz	CITES MA
Nigeria	Mark Ofua	St. Marks Animal Hospital
Nigeria	Olajumoke Morenikeji	PCWGN
Nigeria; Republic of Congo	Dan Ingram	University of Stirling
Pakistan	Tariq Mahmood	PMAS Arid-Agriculture University
Philippines	Atty Adelle	PCSDS
Philippines	Maria Josefa Veluz	National Museum of Natural History
Philippines	Lucy Archer	ZSL
Philippines	Glenn Maguad	BMB Wildlife Rescue Centre
Republic of Congo	Tiffany Golbert	PALF/EAGLE
Rwanda	Richard Muvunyi	RDB, Rwanda
Singapore	Anna Wong	NParks
South Africa	Ray Jansen	African Pangolin Working Group
South Africa	Antionette Kotze	SANBI
South Sudan	Thomas Lado	University of Juba
Sri Lanka	Priyan Perera	Sri Jayewardenepura University
Togo	Gabriel Hoinsoude Segniagbeto	CITES SA + University of Lome
Uganda	Stuart Nixon	Chester Zoo
Uganda	Naomi Matthews	Chester Zoo
Uganda	Sam Isoke	Chester Zoo
Zambia	Terry Njovu	Department of National Parks and Wildlife (CITES MA)

Annex 2. Data collection protocol

Implementation of CITES Decision 18.239 on Pangolins (*Manis* spp.): Developing conversion parameters to estimate the number of pangolins in trade

Data Collection Protocol

This protocol is designed to guide you in the collection of data to help implement CITES Decision 18.239 on pangolins (*Manis* spp.), specifically: (1) scale mass for individual pangolin specimens, and (2) scale morphological measurements and descriptions of the scales and specimens.

We describe three different tiers of data collection. For those who have limited time and resources, please follow Tier 1 (10 photographs and 1 scale mass measurement per specimen). For participants who want to contribute more significantly, please also follow Tier 2 (19 photographs and 7 scale mass measurements per specimen). And, for participants who want to have maximum input to the effort, please also then follow Tier 3 (same 19 photographs and 7 scale mass measurements per specimen, plus 3 scale dimension measurements for each of 140 scales for 1 specimen only). Each Tier builds on the prior one, so please read this entire document before starting data collection.

We highly recommend to connect with the project leads as you collect data, especially for the first specimen, to clear up any potential confusion. Reach us on WhatsApp on the contact details provided.

Minimum required materials. For each Tier we indicate any additional required materials.

Please be sure to have access to these items before you begin data collection:

- Data collection sheet and pen/pencil, OR enter data directly into provided data collection sheet on a charged laptop.
- Latex or latex-free laboratory / surgical gloves.
- Spring or digital balance with capacity up to 50 kg to weigh pangolin carcasses (see Note).
- Precision digital or spring balance to weigh scales (see Note).
- Needle nosed pliers.
- Heavy duty sack or bucket, if necessary, to use when weighing the pangolin carcass.

- Collecting tray or flat, clean surfaces for organizing removed scales (see Tier Notes).
- Digital camera – either latest smartphone or handheld (see note below).
- Bucket/large container capable of holding a large volume of hot water.
- Stove or burner capable of heating water to boiling.
- Tape measure.

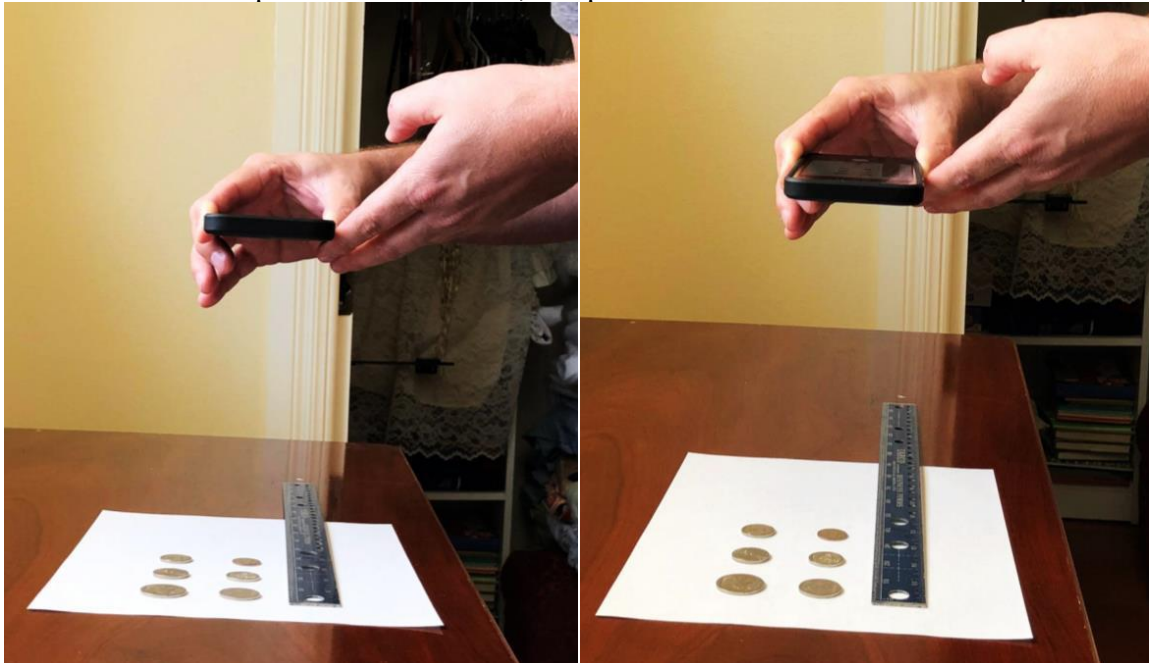
Note on balances: Carcasses of black-bellied, white-bellied, or Philippine pangolins can be weighed with a balance capable of up to 10 kg, while Temminck's, giant, or Indian pangolin carcasses will require a balance capable of up to 40–50kg. It is unlikely that you will be able to use the same balance to weigh both the carcasses and the scales once they have been removed. Scales for the smaller species will weigh less than 500 g total (even as little as 10-20 g for the different body regions), while scales for the bigger species may weigh as much as 3.5-5 kg. Please use the most precise balance available to you.

Note on photographs: All photographers will retain copyright of their photos and will be credited in all publications and other uses of the photograph. Photographs must be taken from standard angles and with the highest quality and resolution possible. In many cases, we will subsequently use photographs to collect data using computer software and/or in identification guides, neither of which will be possible if the photo is blurry, out of focus, or poorly lit. Photographs of whole carcasses or skins will be used for documentation purposes only.

Photographs of scales will be used for digital measurements, analysis of scale morphology and morphometrics, and identification purposes. Please follow these instructions precisely:

Photograph each scale / group of scales directly from above at a perpendicular angle to the surface that they are laying on. Please include a size reference in the photo (e.g., tape measure). These photographs will be used for subsequent analysis and require the correct angle of view. Please make every effort to ensure that the angle of the camera lens to the scales is direct and flat, and that the scales are laying on a flat surface. See Fig. 1 for illustration of correct camera position.

Fig. 1 Taking proper photographs of pangolin scales. Note the organization of the “scales” (represented here with coins) on a clean white surface, flat angle of view of the camera lens positioned as close as possible to the scales, and presence of a size reference in the photo.



Preliminary Steps for all Tiers

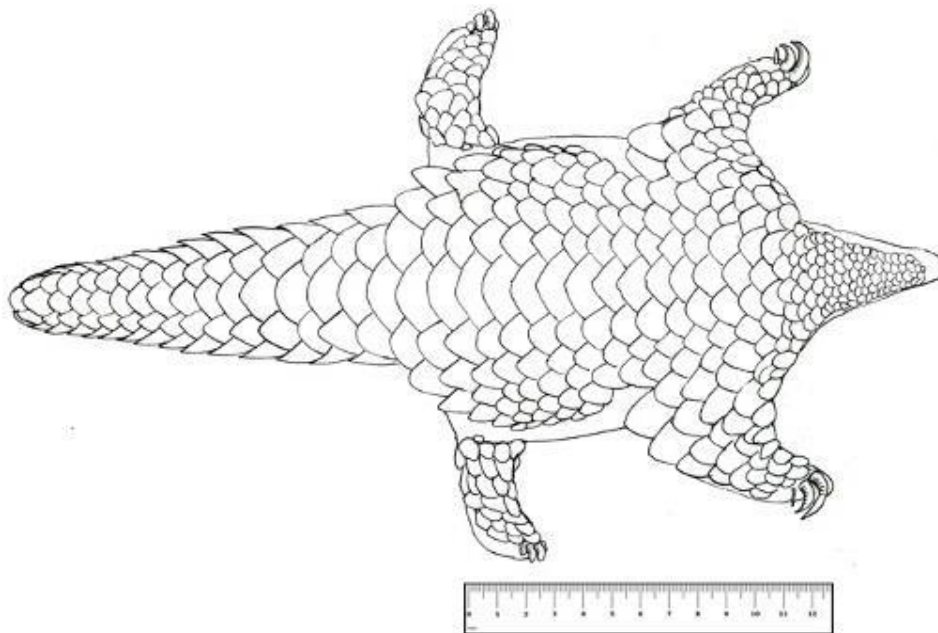
**Remember to wear gloves!*

Treatment of the Carcass or Skin:

1. Assign and record a specimen ID number that will be used to individually identify all sampled specimens and their associated data. Please use the following format: Species_Country_Participant_Number. So, if Matt Shirley is collecting data on black-bellied pangolins from Cote d'Ivoire, the ID for the first specimen would be: Ptetradactyla_IvoryCoast_Shirley_01.
2. Remove the carcass or skin from any bag, box, etc... and thaw if frozen. Note: To defrost, place the pangolin in a secure area out of direct sunlight for up to 12 hours, checking periodically after a few hours, until thawed.
3. Remove any large amounts of dirt, earth, or other debris that might have built up on the carcass.
4. Note any anomalies, such as missing scales or other body parts. Also note whether the specimen is a whole carcass or only a skin. Note: if the specimen has significant anomalies (e.g., missing limbs or tail) contact the project leaders to discuss the best way forward.
5. Record the sex and estimated demographic class of the specimen (e.g., juvenile or adult).

6. Weigh the intact carcass or skin and record the mass. Note: do not forget to zero the balance and subtract the weight of any container being used to hold the carcass, as relevant, before recording the mass.
7. With the dorsal side up, measure the length of the animal from tip of snout to the base of the tail, and from the base to the tip of tail. Record the measurements in the datasheet. Note: do not forget to record the units for each measurement (e.g., cm).
8. Photograph the whole carcass or skin both dorsally and ventrally directly from above. Ideally the carcass or skin will be stretched out straight/flat. Please include a size reference in the photo (e.g., tape measure). See Fig. 2. Note: Save all photographs in a folder on your computer labelled with the specimen ID number.

Fig. 2 Pangolin skin photographed for documentary purposes. Note the position of the pangolin, angle of view of the photograph, and presence of a size reference in the photo. If not possible to capture the full body in a single frame, two photos would be acceptable. Do not forget both ventral and dorsal views.

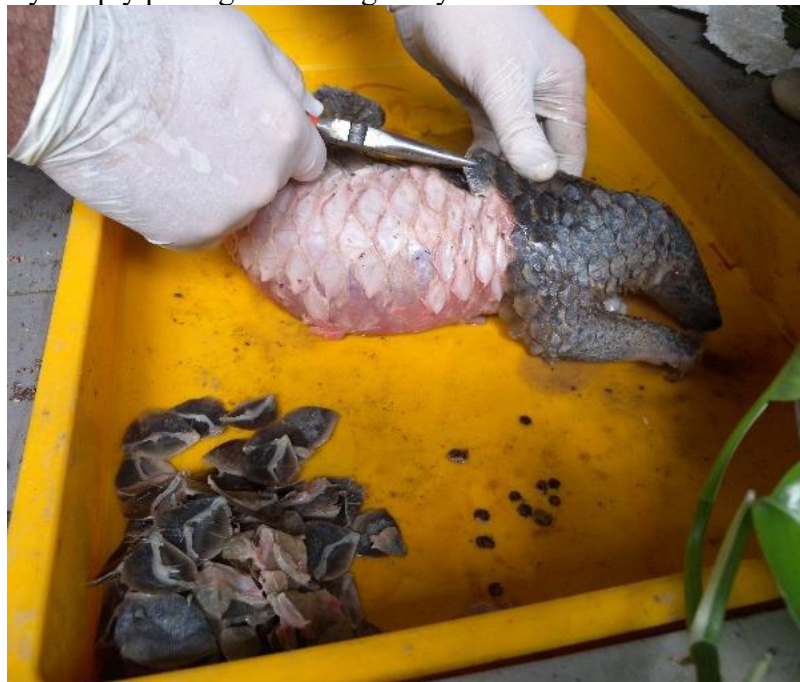


Removal of Scales:

1. Please note that there may be other methods to remove scales from a pangolin carcass. We highly recommend the following method because scales are easy to remove with no damage. You can use any mechanical means to remove scales as you see fit, but please do not burn the specimen. The most important consideration is that the scales do not contain bits of skin or flesh when being weighed. Note: if you accidentally break any scales while removing them, please make sure all pieces are included when weighing.

2. Prepare a bucket/pot of boiling water. Note: remove water from heat source before adding the carcass or skin.
3. Submerge the carcass/skin in the hot water for up 5 minutes. Test if the scales can be easily removed with your fingers or a pair of pliers after 2-3 minutes. If not, then place the pangolin back in the water for 30-60 more seconds at a time until they can be easily removed. Note: if the pangolin remains in the hot water for too long, you risk removing large bits of skin and flesh with the scales. If this happens, please remove any excess skin that comes off with the scales and place it back on the pangolin carcass/skin prior to weighing.
4. Remove the scales using your fingers or pliers by pulling them out of the scale bed and away from the carcass/skin (Fig. 3). Note: please refer to Tier 1 and Tier 2 prior to proceeding with this step.
5. Allow any water on the surface of the carcass/skin to dry completely, and then weigh and record its mass as above. Note: do not forget to zero the balance and subtract the weight of any container being used to hold the carcass, as relevant, before recording the mass.

Fig. 3 Removal of pangolin scales. After soaking in hot water, scales are easily removed with fingers or pliers by simply pulling or bending away from the scale bed.



Tier 1

Expected Data Output: 10 photographs and 1 scale mass measurement per specimen

Extra materials required: None.

Scale Photographs:

1. While removing scales from the carcass/skin, please randomly select 20 representative scales from each body region (see a-g below) to photograph. **Note:** You will have 7 groups of 20 scales to photograph. Generally speaking the scales in each of the regions below will be a different size and shape to the adjoining body region; this will facilitate your ability to determine which scales should fall into which region. See **Fig. 4** for an indication of where to separate groups.

- a. Head – All scales on the head, including those with scale bed even to and anterior the posterior-most part of the skull.
- b. Forelimbs – All scales on the front legs, including those with scale bed to the top of the humeral articulation.
- c. Hindlimbs – All scales on the back legs, including those with scale bed to the top of the femoral articulation.
- d. Trunk – All scales not on the head, limbs, or tail (dorsal, lateral and ventral).
- e. Tail dorsal – All scales on the dorsal surface of the tail.
- f. Tail lateral – All scales on the lateral surfaces of the tail.
- g. Tail ventral – All scales on the ventral surface of the tail.

2. Organize the scales for each body region on a plain white or black surface (e.g., sheet of printer paper) as shown in **Fig. 5**.

Fig. 4 Pangolin scale body regions. Each body region is labelled as above. Please note that the d) Trunk scales are those that fall **within** the dotted purple line, while those of adjacent regions (a – Head, b – Forelimbs, c – Hindlimbs, and e-g – Tail) are those **outside** of the dotted purple line. For the tail, we additionally indicate e) Tail Dorsal (blue dots) and f) Tail Lateral (orange dots), noting that g) Tail Ventral are not visible in this diagram.

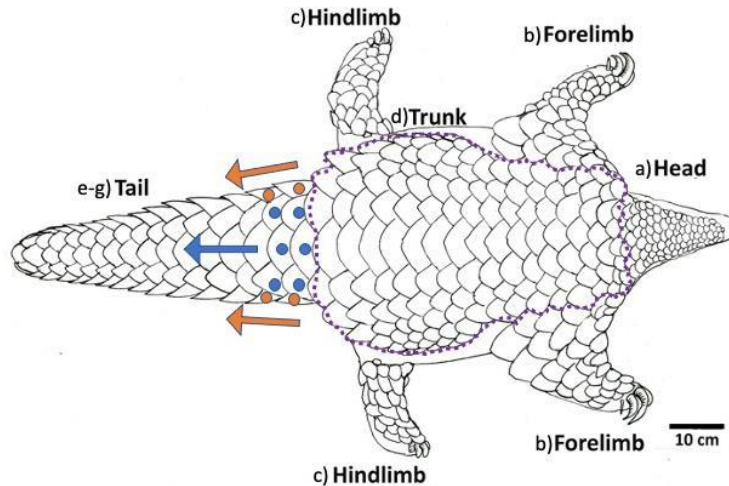


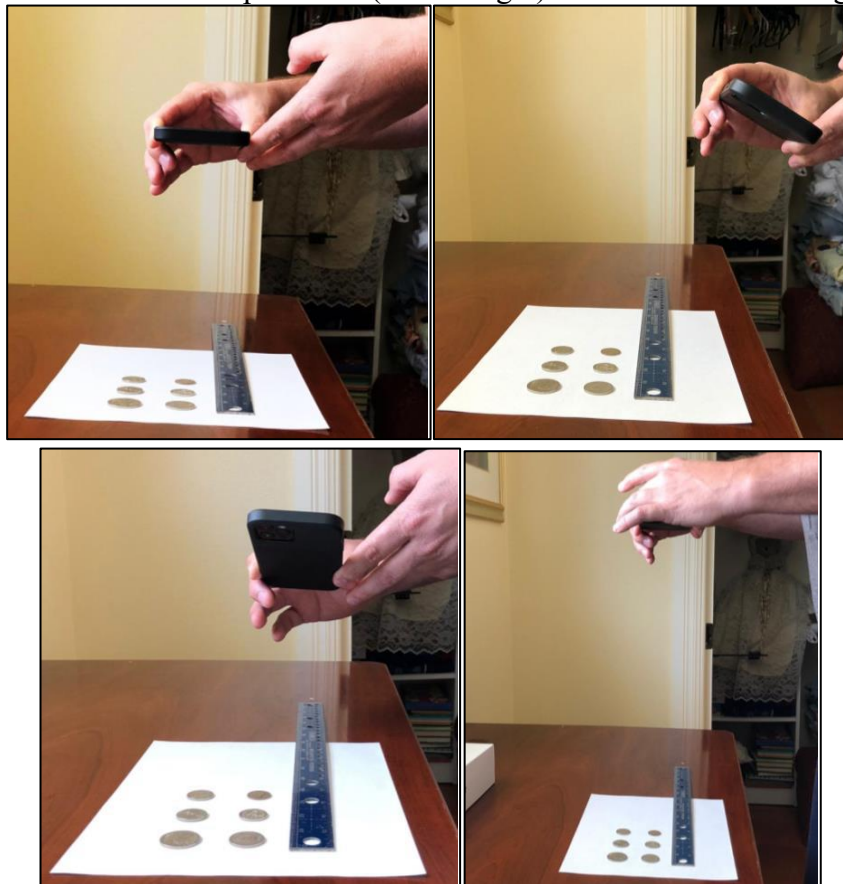
Fig. 5 Twenty representative body scales from black-bellied pangolin (*Phataginus tetradactyla*). Note the arrangement of scales in organized rows and columns by size, inclusion of a diversity of scale size and shapes in the sample, and the presence of a size reference in the photo.



3. Photograph each group of scales as described above and illustrated in **Figs. 1** (above) and **Fig. 6** (below). **Note:** Remember that these photographs will be used for subsequent analysis and require the correct angle of view. Please make every effort to ensure the correct angle of view.

4. Please save photographs in the specimen folder created in the previous section, saving each with a unique file name as follows: ID#_HindLimbs, ID#_ForeLimbs, etc... (e.g., Ptetradactyla_IvoryCoast_Shirley_01_HindLimbs).
5. Select 1 scale that, in your opinion, **best** represents each body region in terms of its characteristic shape and colour. Arrange them on the same black or white surface as shown in **Fig. 7**, and photograph them as in step 3. **Note:** these photographs will be used in the identification guide, and so it is of utmost importance that they are publication quality (i.e., not blurry, well lit, high-res).
6. Please save this photograph in the specimen folder created in the previous section, using a file name as follows: ID#_Scales_Best (i.e., Ptetradactyla_IvoryCoast_Shirley_01_Scales_Best).

Fig. 6 Taking proper photographs of pangolin scales. The top left photo represents the correct position, while in the other three the angle of view is not correct (upper right, bottom left) or the camera is too far from the scale specimens (bottom right). Please refer also to Fig. 1.



Scale Mass Measurements:

1. As you remove the scales, please spread them out evenly on a clean surface and allow them to dry completely. You can dry them in the sun or indoors (A/C will help). It should take 6-24 hours for them to dry completely. **Note:** Do not forget to add the 140 photographed scales back into the mix.
2. Once the scales are dry, **use the most precise balance available** to weigh the scales. A balance with precision to two decimal places (e.g., x 0.01 g) would be ideal. Scales can be weighed in a single lot or can be divided up and weighed in multiple lots (e.g., by body region) depending on the shape, form, and capacity of your balance. **Note:** please ensure that each scale is weighed only once. Do not forget to zero the balance and subtract the weight of any container being used to hold the scales, as relevant, before recording the mass.
3. Record the total scale mass on the data sheet with corresponding specimen ID number.

Fig. 7 Individual scales that best represent the body regions of black-bellied (right; *Phataginus tetradactyla*) and white-bellied pangolins (left; *P. tricuspis*). Note that this photo only includes four body regions from each species, we are requesting all seven body regions from you.



Tier 2

Expected Data Outputs: Same 10 photographs from Tier 1, plus 9 new photographs, plus 7 scale mass measurements per specimen.

Extra Materials Required: Access to a large, flat surface (see below).

Scale Photographs:

1. While removing scales from the carcass/skin, organize them on the large, flat surface following their body plan in the order that they were removed as shown in **Fig. 8-L**.
2. Photograph first the entire group, as shown in **Fig. 8-L**, followed by close-up photographs of the group of scales from each body region (defined above, as shown in **Fig. 8-R**). **Note:** this may result in 9 photographs because each of the 4 limbs could be photographed separately.
3. Please save photographs in the same specimen folder previously created.
4. Select 20 representative scales from each of the seven body regions (as defined above) and follow the procedure outlined above in **Tier 1 – Scale Photographs** – steps 1 to 4.
5. Once finished, return the 20 scales to the others from their body region group and proceed to scale measurements below.

Scale Mass Measurements:

1. Follow the procedure from **Tier 1 – Scale Mass Measurements** – steps 1 to 3, however, record the weights of the groups of scales from each body region independently. **Note:** this will result in **7 individual mass measurements per specimen**. Do not forget to zero the balance between measurements and subtract the weight of any container being used to hold the scales, as relevant, before recording the mass.
2. Record the scale mass of each body region on the data sheet with corresponding specimen ID.

Tier 3

Expected Data Outputs: Same 19 photographs and 7 scale mass measurements per specimen from Tier 2, plus 3 scale dimension measurements for each of 140 scales for 1 specimen only.

Extra Materials Required: 1) Access to a large, flat surface. 2) Precision callipers or a tape measure.

Scale Photographs:

1. Follow **Tier 2 – Scale Photographs** – steps 1 to 4.

Scale Measurements:

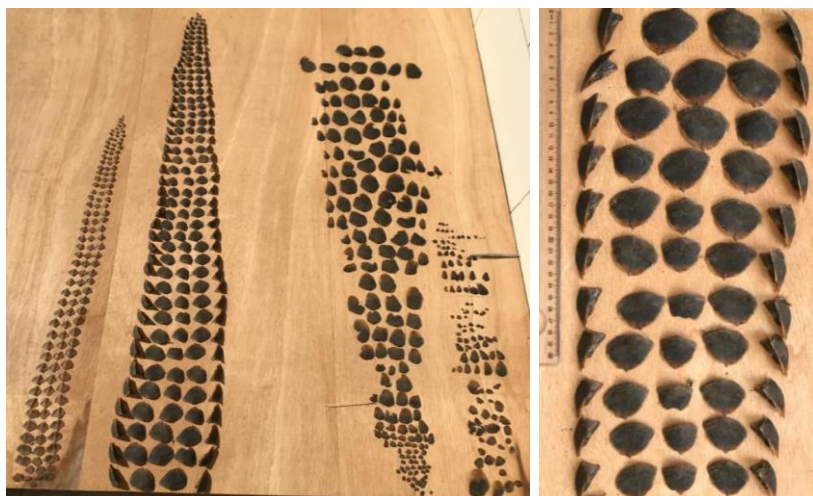
1. Follow **Tier 2 – Scale Mass Measurements** – steps 1 and 2.

2. For one specimen only, do the following for each of the 20 scales per body region (140 total measurements per dimension): a. Use the callipers (or tape measure) to measure the single point of thickest thickness of each scale.

b. Try to bend and manipulate each scale with your fingers and classify the “resistance” of the scale from 1 to 5, where 1 are scales that are very pliable and 5 are scales that are not pliable at all (e.g., “hard as a rock”). **Note:** we understand that this is a subjective exercise, please do the best you can to be objective and consistent across scales and specimens within your sample.

c. Weigh each of the 140 scales individually.

Fig. 8 Black-bellied pangolin scales removed from the carcass and arranged according to the body plan (Left) and close up of the dorsal and lateral tail scales (Right). In the left photo, the scales are grouped, from left to right, ventral tail, dorsal+lateral tail, head+body, fore+hind limbs.



Annex 3. Philippines data collection protocol

Implementation of CITES Decision 18.239 on Pangolins (*Manis* spp.): Developing conversion parameters to estimate the number of pangolins in trade

Data Collection Protocol – De-scaled Philippine Pangolins

This protocol is designed to guide Philippine collaborators in the collection of data to help implement CITES Decision 18.239 on pangolins (*Manis* spp.). This specific protocol is a modified version of the global data collection protocol due to the unique situation that exists in the Philippines, where de-scaled carcasses and scale stockpiles exist independently, but where whole pangolin carcasses are unlikely to be available. The steps outlined here will help collect data on: (1) mass of de-scaled pangolins, (2) scale frequency from pangolin carcasses, and (3) scale mass expectations for individual pangolin specimens. Please read through this guidance in its entirety before starting data collection. We highly recommend connecting with the project leads before you collect data, especially for the first specimen, to clear up any potential confusion. Reach us on WhatsApp: Dan Challender (+44 7745 547585) and/or Matt Shirley (+1-352-562-2243).

Please be sure to have access to these items before you begin data collection:

- Data collection sheet and pen/pencil OR enter data directly into provided data collection sheet on a charged laptop.
- Latex or latex-free laboratory / surgical gloves.
- Spring or digital balance with capacity up to 10 kg to weigh pangolin carcasses (see Note).
- Precision digital or spring balance to weigh scales (see Note).
- Heavy duty sack or bucket, if necessary, to use when weighing the pangolin carcass.
- Digital camera – either latest smartphone or handheld (see note below).
- Tape measure.
- Collecting tray.
- 2 x different coloured heavy duty marker pens / 2 x different coloured small stationary stickers.

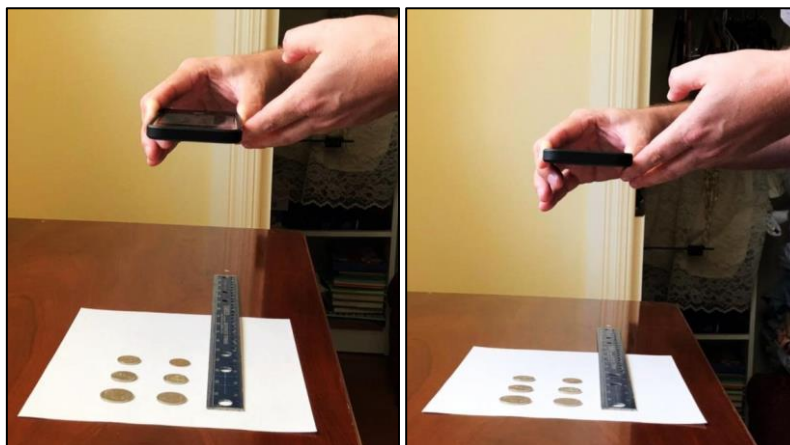
Note on balances: Carcasses of Philippine pangolins can be weighed with a balance capable of up to 10 kg. It is unlikely that you will be able to use the same balance to weigh both the carcasses and the scales. Scales for the Philippine pangolin will weigh less than 500 g total. Please use the most precise balance available to you.

Note on photographs: All photographers will retain copyright of their photos and will be credited in all publications and other uses of the photograph. Photographs must be taken from standard angles and with the highest quality and resolution possible. In many cases, we will subsequently use photographs to collect data using computer software and/or in identification guides, neither of which will be possible if the photo is blurry, out of focus, or poorly lit. Photographs of whole carcasses or skins will be used for documentation purposes only.

Photographs of scales will be used for digital measurements, analysis of scale morphology and morphometrics, and identification purposes. Please follow these instructions precisely:

Photograph each scale / group of scales directly from above at a perpendicular angle to the surface that they are laying on. Please include a size reference in the photo (e.g., tape measure). These photographs will be used for subsequent analysis and require the correct angle of view. Please make every effort to ensure that the angle of the camera lens to the scales is direct and flat, and that the scales are laying on a flat surface. See **Fig. 1** for illustration of correct camera position.

Fig. 1 Taking proper photographs of pangolin scales. Note the organization of the “scales” (represented here with coins) on a clean white surface, flat angle of view of the camera lens positioned as close as possible to the scales, and presence of a size reference in the photo.



Key steps

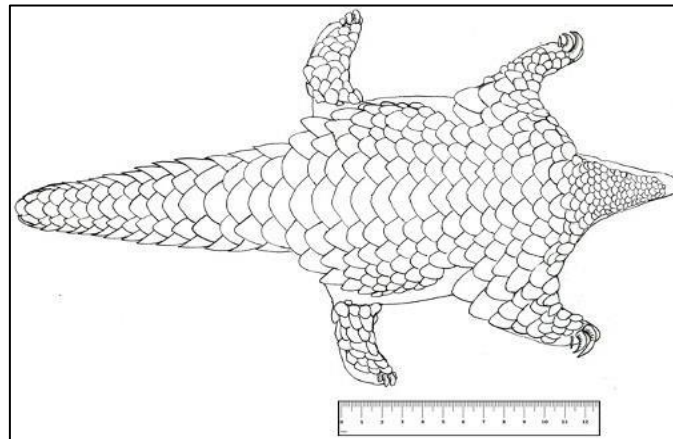
1. Prepare and weigh the carcass (including photographing the specimen).
2. Count the scale beds on the specimen.
3. Match scales from stockpiles to body regions on de-scaled specimen.
4. Take scale photographs.
5. Measure scale mass.

Prepare and weigh the carcass

1. Assign and record a specimen ID number in the accompanying datasheet that will be used to individually identify all sampled specimens and their data. Please use the following format: Species_Country_Participant_Number. So, if Matt Shirley is collecting data on black-bellied pangolins from Cote d'Ivoire, the ID for the first specimen would be: Ptetradactyla_IvoryCoast_Shirley_01.
2. Remove the carcass from any bag, box, etc. and thaw if frozen. **Note:** To defrost, place the pangolin in a secure area out of direct sunlight for up to 12 hours, checking periodically after a few hours, until thawed.
3. Remove any large amounts of dirt, earth, or other debris that might have built up on the carcass.
4. Note any anomalies, such as missing scales or other body parts, including if the animals have been eviscerated, on the datasheet. If in doubt, contact the project leaders for clarification.
5. Record the sex and estimated demographic class of the specimen (e.g., juvenile or adult).
6. Weigh the carcass and record the mass. **Note:** do not forget to zero the balance and subtract the weight of any container being used to hold the carcass, as relevant, before recording the mass.
7. With the dorsal side up, measure the length of the animal from tip of snout to the base of the tail, and from the base to the tip of tail – take this measurement alongside the specimen rather than on the specimen itself. Record the measurements in the datasheet. **Note:** do not forget to record the units for each measurement (e.g., cm).
8. Photograph the carcass dorsally and ventrally directly from above. Ideally the carcass will be stretched out straight/flat. Please include a size reference in the photo (e.g., tape measure). See **Fig. 2**. **Note:** Save all photographs in a folder on your computer labeled with the specimen ID number. **This will involve producing 1–2 high quality photos.**

Fig. 2 Pangolin skin photographed for documentary purposes. Note the position of the pangolin, angle of view of the photograph, and presence of a size reference in the photo. If not

possible to capture the full body in a single frame, two photos would be acceptable. Do not forget both ventral and dorsal views.



Count the scales on the specimen

1. The next step is to estimate scale frequency, i.e., count the number of scales each specimen had before they were removed. To do this, systematically count the number of scale beds on each specimen. A “scale bed” is the equivalent of a nail bed on a human finger and indicates where a scale used to be (**Fig. 3**). It will be important to mark each scale bed once you have counted it using a heavy-duty marker pen or small stationary stickers to avoid double-counting (**Fig. 4**). The easiest way to do this will be to choose an appendage (e.g. limb) and start there, marking each scale bed as it is counted before moving on to another part of the body. Do not forget to include the scales on the forehead and ventral surface (underside) of the tail.
2. Please record the number of scales independently per body region (see Fig. 6 for the body regions). This will facilitate later steps that necessitate pulling scales from the stockpiles to reconstitute the individual pangolin scale mass.
3. Record the number of scales per body region and the total number of scales on the datasheet.

Fig. 3 Pangolin being de-scaled. The diamond-shaped scales beds are clearly visible. Scale beds shown with red arrow.



Fig. 4 Mark the scales as you count them using a heavy-duty marker pen or small stationary stickers. Note in this image the specimen still has the scales attached; blue marks are visible.



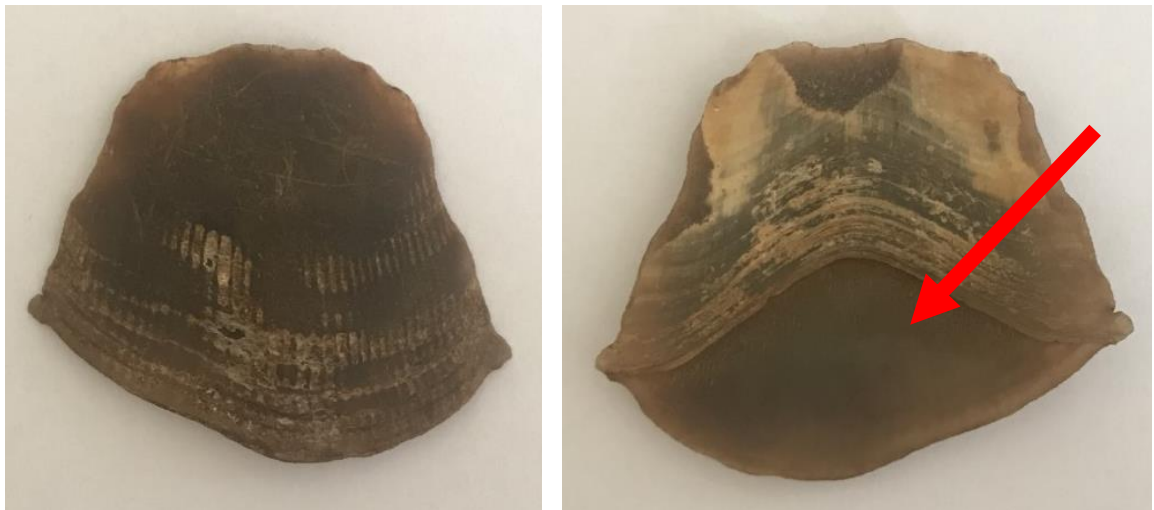
Match Scales from the Stockpile to Body Regions

1. The next step is to match up scales from the scale stockpile with each scale bed on each pangolin carcass. Two pieces of information will be critical to doing this accurately: (1) **scale size / shape** and (2) **scale bed size / shape**. See notes below.
2. To match a scale to a scale bed, consider the size and shape of the scale and the size and shape of the scale bed and consider whether it is feasible that an individual scale could have been attached to a particular scale bed. See also the supplementary file showing general expectations of scale size/shape per body region for the Sunda pangolin. This will, ideally, help you determine *a priori* which scales should have come from which body region. Generally speaking the scales in each of the regions below will be a different size and shape

to the adjoining body region; this will facilitate your ability to determine which scales should fall into which region.

3. Once you have determined the type/size/shape of scale that goes with each body region, please search the stockpile and set aside the number of scales for each region that matches the frequency of scale beds determined above. Please keep them grouped by body region as this will facilitate later steps. **Note – you do not need to match each scale to a single scale bed as if completing a 3D pangolin puzzle, simply determine the type/size/shape of scale that goes with each body region and pull the expected number of scales from the stockpile.**

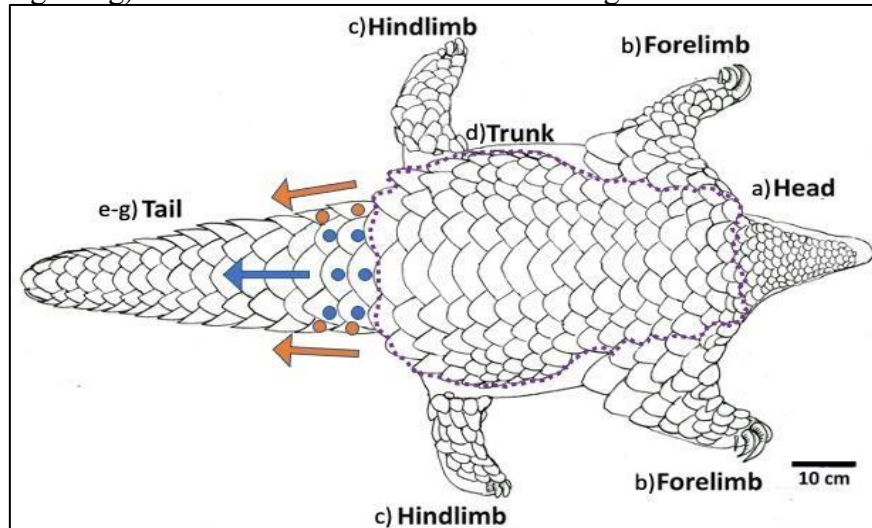
Fig. 5. Pangolin scale from top (left) and “underside” of the same scale showing the diamond shaped part of the scale that was attached to the body of the pangolin (right; red arrow).



Scale size – The size of scales varies on a pangolin from very small scales on the head (up to the size of a small coin), to larger scales on the dorsum, reaching the size of a large coin on the Philippine pangolin. The scales on the dorsum (the back of the animal) are the largest. Scales will overlap with adjacent scales and with the next scale along on the anterior-posterior body axis (i.e., on the scale row from head to tail). You should consider this when matching scales to scale beds.

Scale bed – The scale bed is like a human fingernail bed and comprises the part of the scale which is attached to the body of the pangolin (**Fig. 5**). For a scale to be considered to “fit” a scale bed, it will need to be the correct size *and* have the correct size and shape of the scale bed (see Fig. 5).

Fig. 6 Pangolin scale body regions. Each body region is labelled as above. Please note that the d) Trunk scales are those that fall within the dotted purple line, while those of adjacent regions (a – Head, b – Forelimbs, c – Hindlimbs, and e-g – Tail) are those outside of the dotted purple line. For the tail, we additionally indicate e) Tail Dorsal (blue dots) and f) Tail Lateral (orange dots), noting that g) Tail Ventral are not visible in this diagram.



Take scale photographs

1. Having matched scales to specimens, please randomly select 20 representative scales from each body region (see a-g below) to photograph. Note: You will have 7 groups of 20 scales to photograph. See Fig. 6 for an indication of where to separate groups.
 - a. Head – All scales on the head, including those with scale bed even to and anterior the posterior-most part of the skull.
 - b. Forelimbs – All scales on the front legs, including those with scale bed to the top of the humeral articulation.
 - c. Hindlimbs – All scales on the back legs, including those with scale bed to the top of the femoral articulation.
 - d. Trunk – All scales not on the head, limbs, or tail (dorsal, lateral and ventral).
 - e. Tail dorsal – All scales on the dorsal surface of the tail.
 - f. Tail lateral – All scales on the lateral surfaces of the tail.
 - g. Tail ventral – All scales on the ventral surface of the tail.

This will involve producing 7 high quality photos.

2. Organize the scales for each body region on a plain white or black surface (e.g., sheet of printer paper) as shown in Fig. 7.

Fig. 7 Twenty representative body scales from black-bellied pangolin (*Phataginus tetradactyla*). Note the arrangement of scales in organized rows and columns by size, inclusion of a diversity of scale size and shapes in the sample, and the presence of a size reference in the photo.



Measure scale mass

1. Weigh the mass of all scales per specimen, **using the most precise balance available to you.** A balance with precision to two decimal places (e.g., x 0.01 g) would be ideal. Do not forget to zero the balance and subtract the weight of any container being used to hold the scales, as relevant, before recording the mass.
2. Record the mass on the data sheet with corresponding specimen ID number.

Annex 4. *M. javanica* scale guide for the Philippines

Expectations of scale size/shape per body region based on the Sunda pangolin

This guide should help you determine *a priori* which scales have come from which body region on the Philippine pangolin; it is based on photos of the Sunda pangolins, which is very similar to the Philippine pangolin. Generally speaking the scales in each of the regions below will be a different size and shape to the adjoining body region; this will facilitate your ability to determine which scales should fall into which region. **Please note photos are courtesy of the Singaporean government and should not be shared further.**

Scales on both Sunda and Philippine pangolins vary in size and shape (Fig. 1).

Fig. 1 Scales from different regions of the body on a Sunda pangolin. Note the size of the scales relative to the ruler at the bottom of the image.



Head

The scales are small and are some of the smallest scales on the body (Fig. 2)

Note the size and shape of the scales below (Fig. 2) with reference to the ruler.

Fig. 2 Scales from the head of a Sunda pangolin.



Note the size of the scales on the head (Fig. 3; red circle), and elsewhere, relative to scales on other parts of the body.

Fig. 3 Scales from a Sunda pangolin.



0.1m

Forelimbs

Scales on the forelimbs graduate in size from several larger scales where the forelimb meets the body to smaller scales (similar in size to those on the head) where the forelimbs terminate at the forefeet (Fig. 1 and 4). Note the size of the scales from largest to smallest relative to the ruler. Also note that some of the scales on the forelimbs may be “keeled”, i.e., have a ridge – see example in Fig. 1.

Fig. 4 Scales from the right forelimb of a Sunda pangolin.



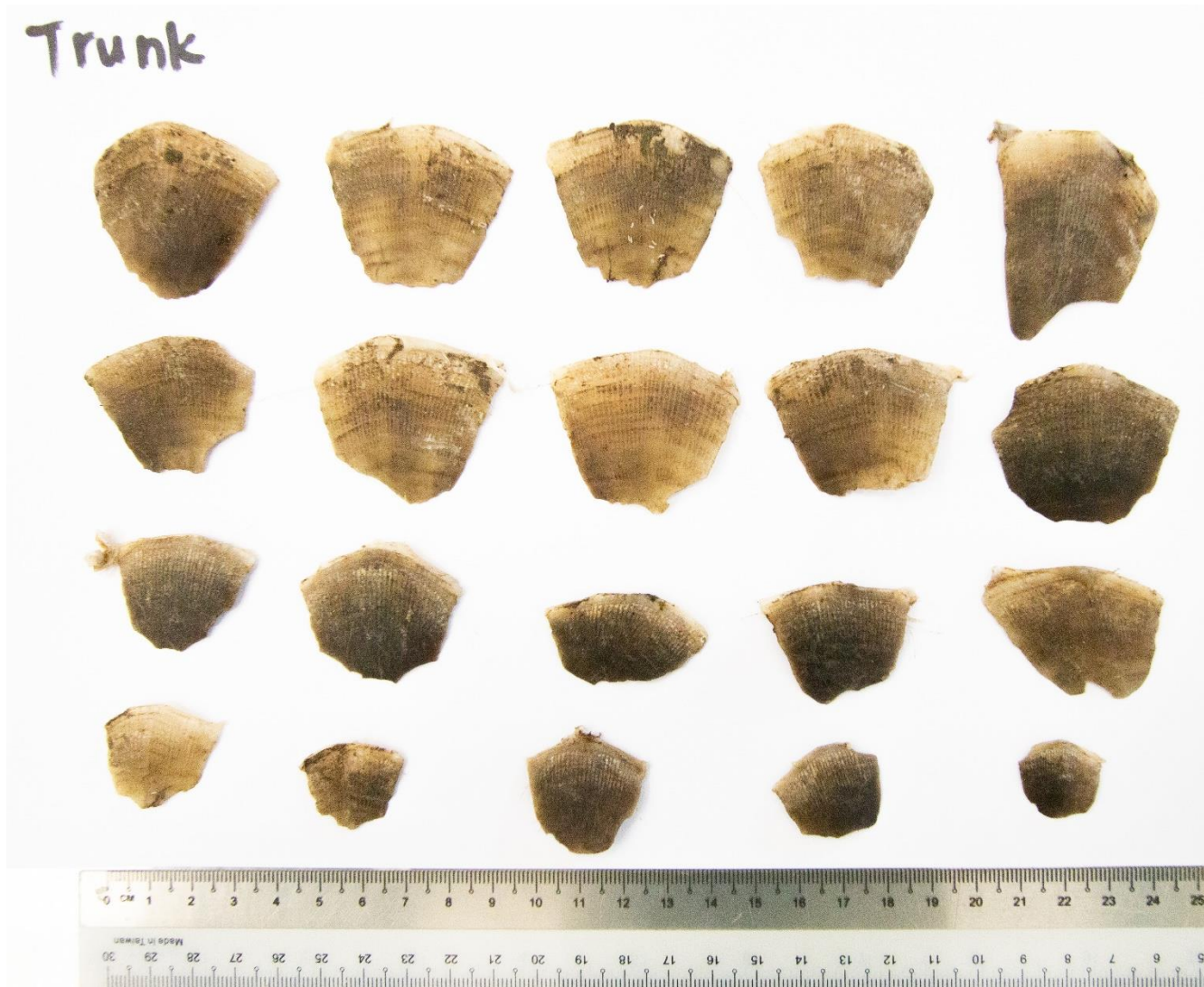
Trunk

The scales on the trunk are some of the largest on the body (Fig. 5 and 6). Note that the scales vary in colour from dark brown to yellow. They may also have thick hairs or bristles attached as in Fig. 1. Scales on the side of the body where they meet the unscaled ventral surface may be keeled.

Fig. 5 Scales on the trunk of a Sunda pangolin. Note that some scales are broken on this specimen (it is a roadkill specimen).



Fig. 6 Scales from the trunk of a Sunda pangolin.



Hindlimbs

Like the forelimbs, the scales on the hindlimbs graduate from larger (close to the body) to smaller (closer to the hindfeet) (Fig. 7) and may be keeled. Also note the relative size of these scales (Fig. 7) to others on other parts of the body in Fig. 3.

Fig. 7 Scales on the right hindlimb of a Sunda pangolin. Keeled scales are visible.



Tail – dorsal

The scales on the dorsal part of the tail will be among the widest on the pangolin (Fig. 1 and 8).

Fig. 8 Dorsal tail scales from a Sunda pangolin.



Tail – lateral

The lateral scales on the tail are kite-shaped, have a sharp point, and would fold around the dorsal and ventral surfaces of the tail (Fig. 1 and 9). They are easily recognisable.

Fig. 9 Lateral tail scales from a Sunda pangolin.



Tail - ventral

The scales on the ventral surface of the tail may appear to be worn or “flat” due to the tail of the pangolin being dragged along the floor when it was walking (Fig. 10 and 11). See also Fig. 1.

Fig. 10. Ventral tail scales from a Sunda pangolin.



Fig. 11. Ventral tail scales from a Sunda pangolin.

